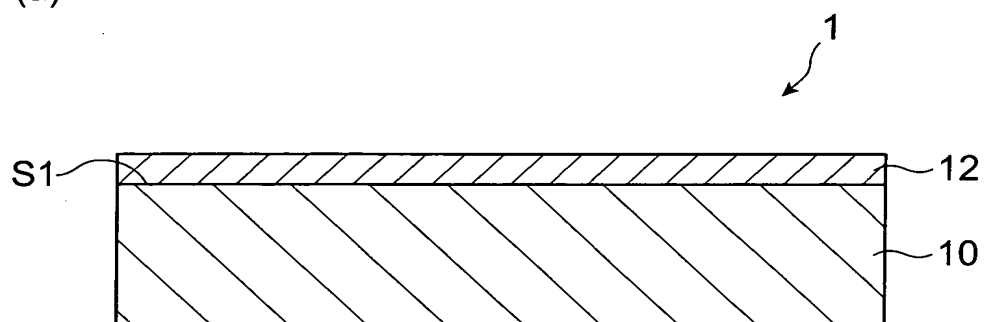
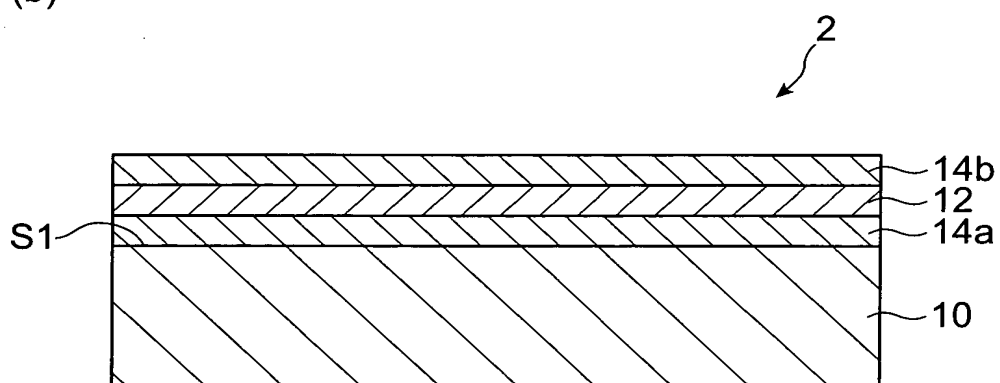


**Fig.1**

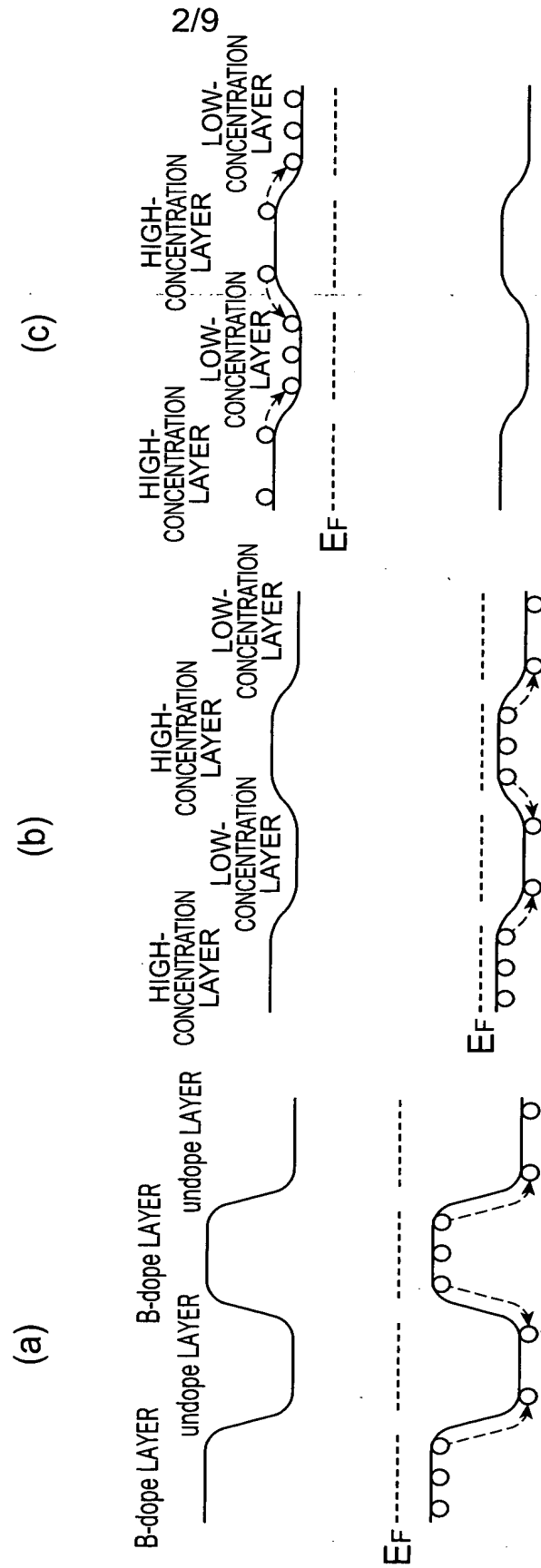
(a)

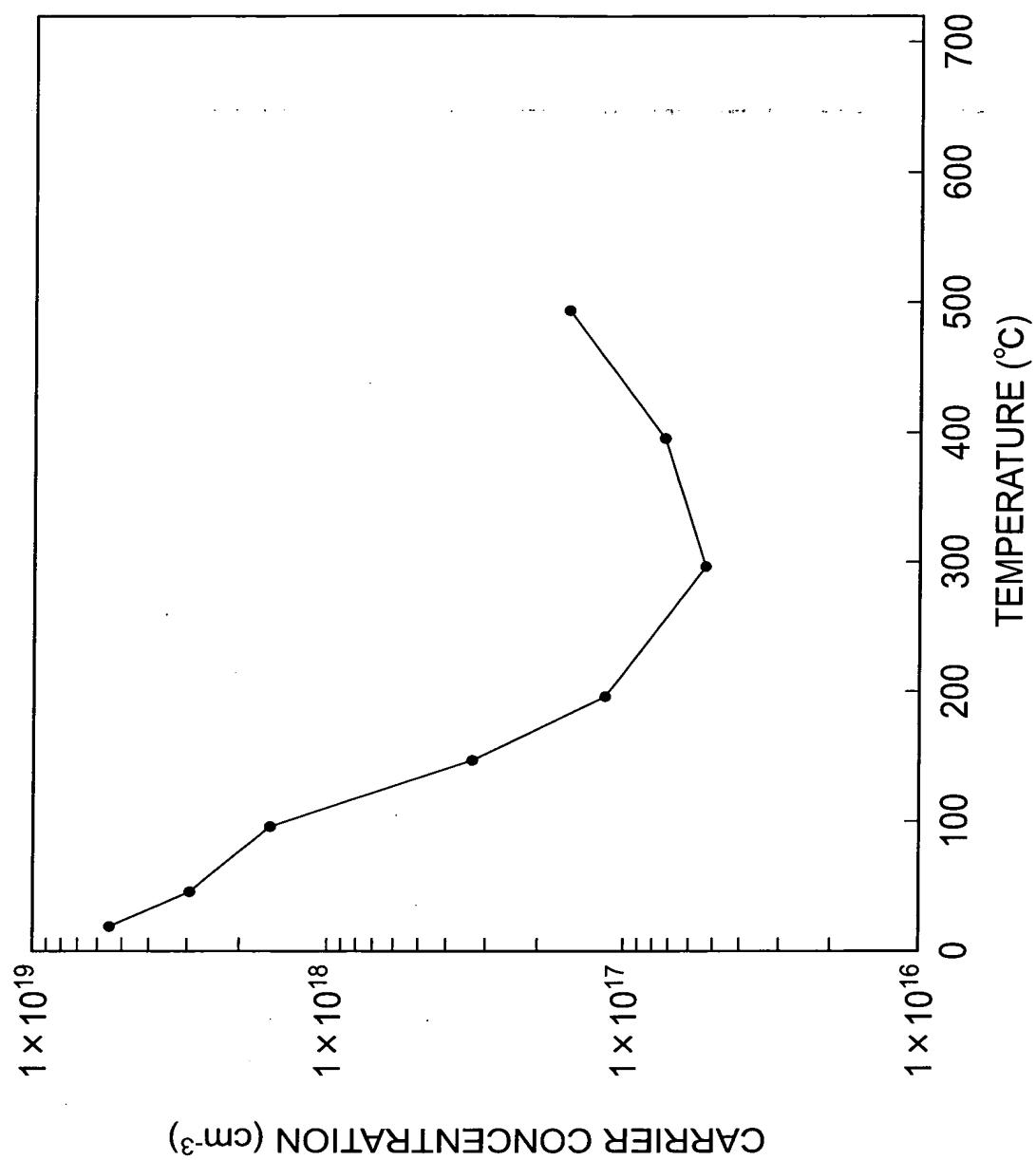


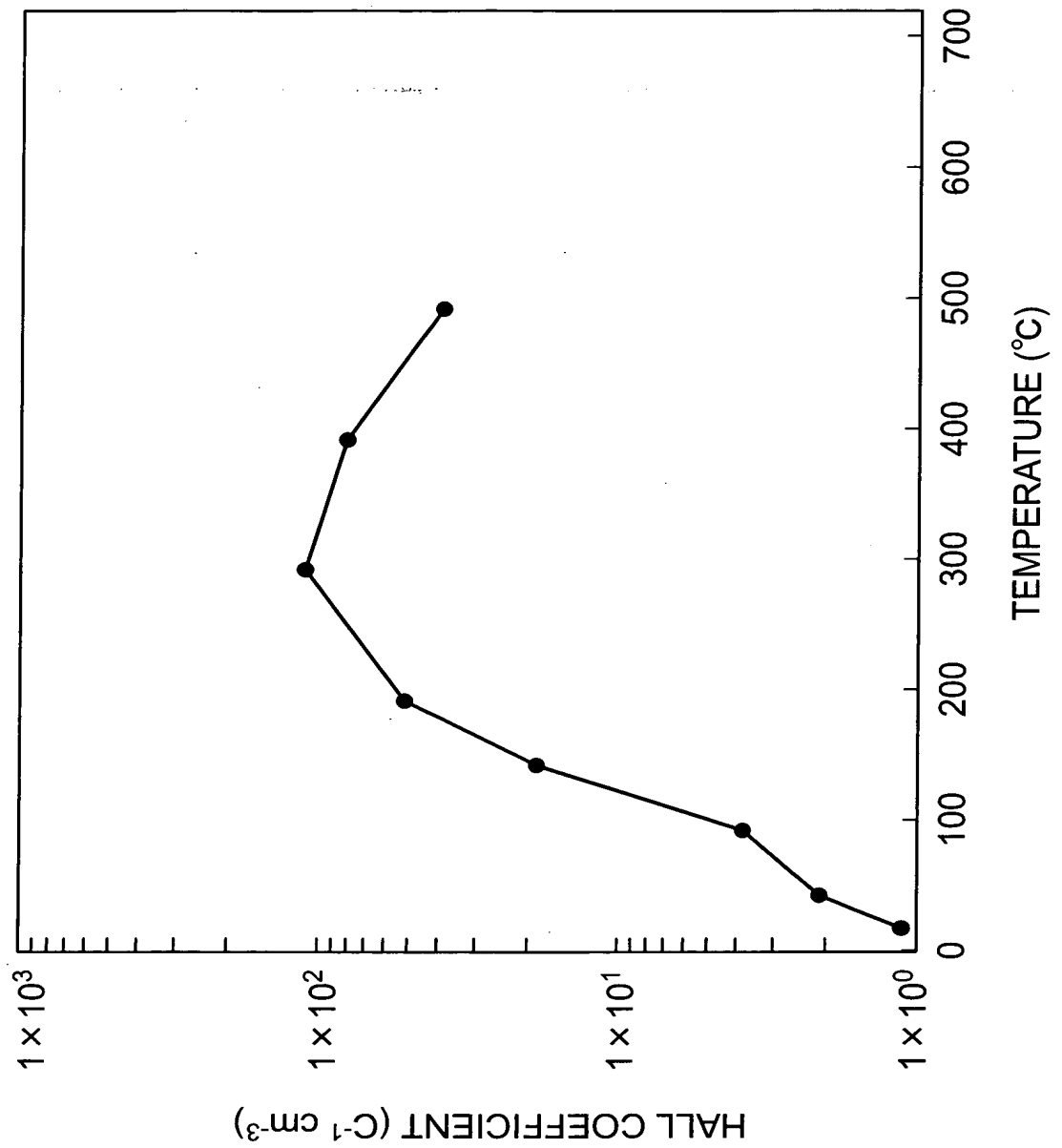
(b)

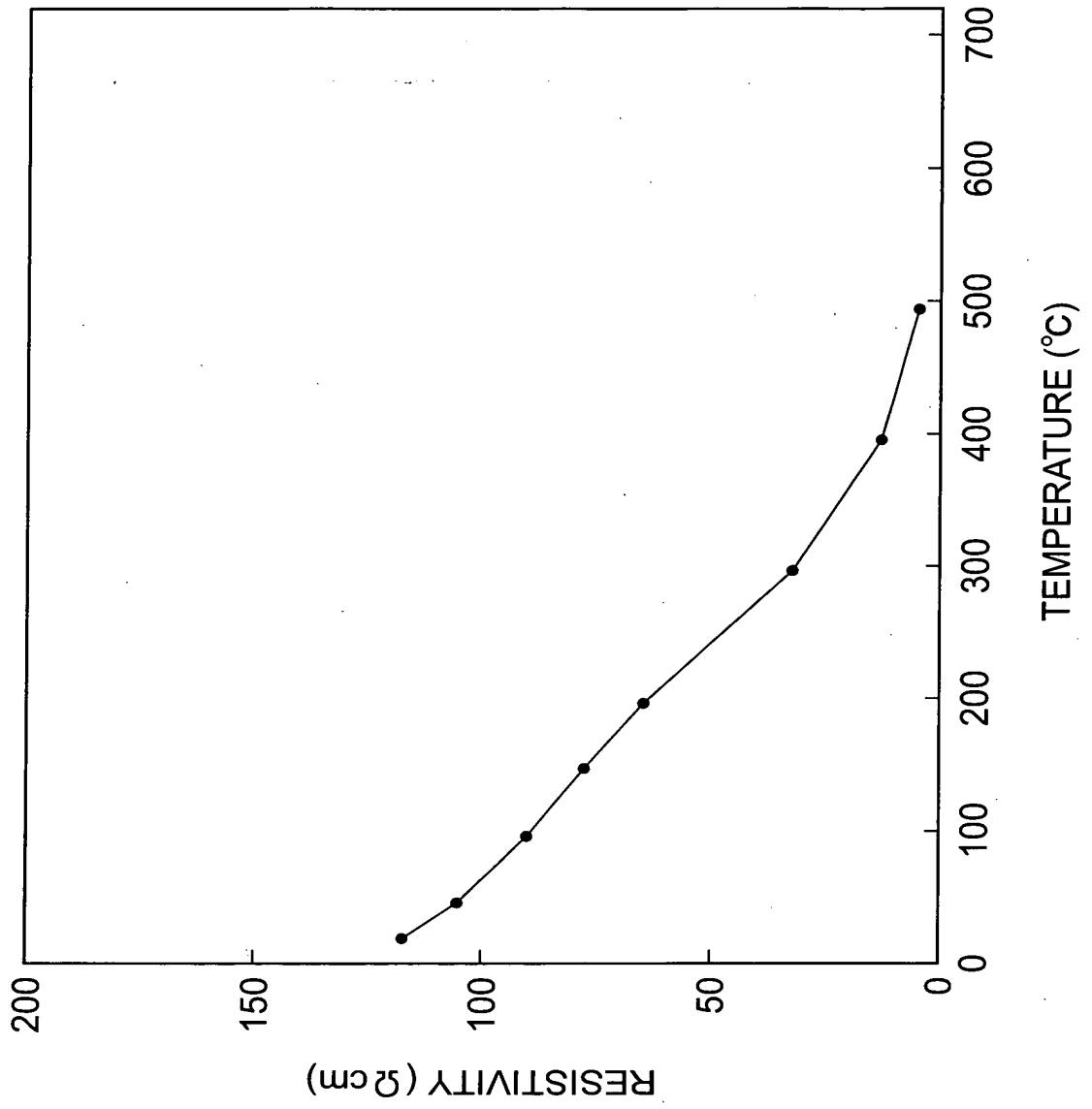


**Fig.2**

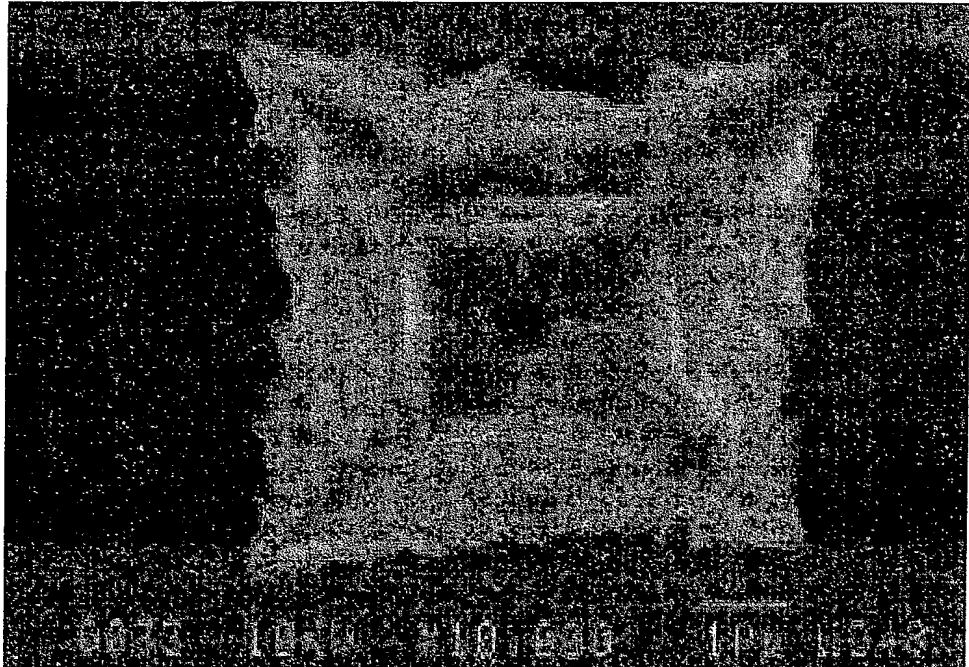


**Fig.3**

**Fig.4**

**Fig.5**

***Fig.6***



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Fig.7

METHANE CONCENTRATION (CH <sub>4</sub> /H <sub>2</sub> ) [%]	PHOSPHINE CONCENTRATION (PH <sub>3</sub> /CH <sub>4</sub> ) [ppm]	N-TYPE DETERMINATION	CORRELATION OF CARRIER CONCENTRATION WITH TEMPERATURE	CORRELATION HALL COEFFICIENT WITH TEMPERATURE	MINIMUM CARRIER CONCENTRATION	RESISTIVITY AT ROOM TEMPERATURE	THRESHOLD VOLTAGE
0.05	20000	N-TYPE	+ (700°C ~ 350°C) - (350°C ~ 100°C)	- (700°C ~ 350°C) + (350°C ~ 100°C)	~ 5 × 10 <sup>15</sup>	100	400
0.03	20000	N-TYPE	+ (700°C ~ 350°C) - (350°C ~ 70°C)	- (700°C ~ 350°C) + (350°C ~ 70°C)	~ 8 × 10 <sup>16</sup>	80	350
0.005	20000	N-TYPE	+ (700°C ~ 350°C) - (350°C ~ 50°C)	- (700°C ~ 350°C) + (350°C ~ 50°C)	~ 2 × 10 <sup>17</sup>	50	300
1.0	22000	NOT DETERMINABLE	NOT OBSERVABLE	NOT OBSERVABLE			
0.5	22000	N-TYPE	+ (700°C ~ 300°C) ALONE	- (700°C ~ 300°C) ALONE	~ 4 × 10 <sup>15</sup>	800	1100
0.1	22000	N-TYPE	+ (700°C ~ 300°C) - (300°C ~ 180°C)	- (700°C ~ 300°C) + (300°C ~ 180°C)	~ 1 × 10 <sup>16</sup>	300	550
0.05	22000	N-TYPE	+ (700°C ~ 300°C) - (300°C ~ 100°C)	- (700°C ~ 300°C) + (300°C ~ 100°C)	~ 3 × 10 <sup>16</sup>	250	500
0.03	22000	N-TYPE	+ (700°C ~ 300°C) - (300°C ~ 50°C)	- (700°C ~ 300°C) + (300°C ~ 50°C)	~ 5 × 10 <sup>16</sup>	200	400
0.005	22000	N-TYPE	+ (700°C ~ 300°C) - (300°C ~ 30°C)	- (700°C ~ 300°C) + (300°C ~ 30°C)	~ 6 × 10 <sup>16</sup>	180	400
0.003	22000	NOT DETERMINABLE	NOT OBSERVABLE	NOT OBSERVABLE			
0.1	18000	N-TYPE	+ (700°C ~ 150°C) - (150°C ~ 60°C)	- (700°C ~ 150°C) + (150°C ~ 60°C)	~ 2 × 10 <sup>15</sup>	700	1000
0.05	18000	N-TYPE	+ (700°C ~ 100°C) - (100°C ~ 20°C)	- (700°C ~ 100°C) + (100°C ~ 20°C)	~ 1 × 10 <sup>15</sup>	900	1000
0.1	11000	N-TYPE	+ (700°C ~ 200°C) ALONE	- (700°C ~ 200°C) ALONE	~ 6 × 10 <sup>14</sup>	1000	1500
0.05	11000	N-TYPE	+ (700°C ~ 150°C) ALONE	- (700°C ~ 150°C) ALONE	~ 8 × 10 <sup>14</sup>	800	1100
0.05	1000	NOT DETERMINABLE	NOT OBSERVABLE	NOT OBSERVABLE			
0.05	1000	N-TYPE	+ (700°C ~ 30°C) ALONE	- (700°C ~ 30°C) ALONE	~ 3 × 10 <sup>13</sup>	20000	2000
0.03	1000	N-TYPE	+ (700°C ~ 30°C) ALONE	- (700°C ~ 30°C) ALONE	~ 4 × 10 <sup>13</sup>	20000	1800
0.005	1000	N-TYPE	+ (700°C ~ 30°C) ALONE	- (700°C ~ 30°C) ALONE	~ 6 × 10 <sup>13</sup>	15000	1500

**Fig.8**

METHANE CONCENTRATION (CH <sub>4</sub> /H <sub>2</sub> ) [%]	PHOSPHINE CONCENTRATION (PH <sub>3</sub> /CH <sub>4</sub> ) [ppm]	Si CONCENTRATION [cm <sup>-3</sup> ]	N-TYPE DETERMINATION	CORRELATION OF CARRIER CONCENTRATION WITH TEMPERATURE	CORRELATION HALL COEFFICIENT WITH TEMPERATURE	MINIMUM CARRIER CONCENTRATION	RESISTIVITY AT ROOM TEMPERATURE	THRESHOLD VOLTAGE
0.05	22000	1 × 10 <sup>19</sup>	N-TYPE	+(700°C~300°C) -(300°C~100°C)	-(700°C~300°C) +(300°C~100°C)	~ 4 × 10 <sup>16</sup>	200	400
0.03	22000	8 × 10 <sup>18</sup>	N-TYPE	+(700°C~300°C) -(300°C~70°C)	-(700°C~300°C) +(300°C~70°C)	~ 6 × 10 <sup>16</sup>	150	350
1	1000	3 × 10 <sup>19</sup>	NOT DETERMINABLE	NOT OBSERVABLE	NOT OBSERVABLE			
0.5	1000	1 × 10 <sup>19</sup>	N-TYPE	+(700°C~500°C) ALONE	-(700°C~500°C) ALONE	~ 8 × 10 <sup>14</sup>	1000	1100
0.1	1000	8 × 10 <sup>18</sup>	N-TYPE	+(700°C~300°C) -(300°C~150°C)	-(700°C~300°C) +(300°C~150°C)	~ 4 × 10 <sup>16</sup>	400	600
0.05	1000	3 × 10 <sup>18</sup>	N-TYPE	+(700°C~280°C) -(280°C~80°C)	-(700°C~280°C) +(280°C~80°C)	~ 5 × 10 <sup>16</sup>	200	450
0.5	5000	2 × 10 <sup>18</sup>	N-TYPE	+(700°C~400°C) ALONE	-(700°C~400°C) ALONE	~ 5 × 10 <sup>14</sup>	1500	1500
0.1	5000	8 × 10 <sup>17</sup>	N-TYPE	+(700°C~300°C) -(300°C~150°C)	-(700°C~300°C) +(300°C~150°C)	~ 1 × 10 <sup>16</sup>	500	700
0.05	5000	2 × 10 <sup>17</sup>	N-TYPE	+(700°C~250°C) -(250°C~50°C)	-(700°C~250°C) +(250°C~50°C)	~ 2 × 10 <sup>16</sup>	300	500
0.5	1000	9 × 10 <sup>18</sup>	N-TYPE	+(700°C~200°C) ALONE	-(700°C~200°C) ALONE	~ 1 × 10 <sup>14</sup>	7000	2000
0.03	1000	10 × 10 <sup>16</sup>	N-TYPE	+(700°C~200°C) ALONE	-(700°C~200°C) ALONE	~ 2 × 10 <sup>14</sup>	4000	1800



Fig.9

METHANE CONCENTRATION (CH <sub>4</sub> /H <sub>2</sub> ) [%]	PHOSPHINE CONCENTRATION (PH <sub>3</sub> /CH <sub>4</sub> ) [ppm]	Si CONCENTRATION [cm <sup>-3</sup> ]	N-TYPE DETERMINATION	CORRELATION OF CARRIER CONCENTRATION WITH TEMPERATURE	CORRELATION HALL COEFFICIENT WITH TEMPERATURE	MINIMUM CARRIER CONCENTRATION	RESISTIVITY AT ROOM TEMPERATURE	THRESHOLD VOLTAGE
0.05	22000	$2 \times 10^{19}$	N-TYPE	+(700°C~350°C) -(350°C~80°C)	-(700°C~350°C) +(350°C~80°C)	$\sim 6 \times 10^{16}$	100	350
0.05	5000	$8 \times 10^{18}$	N-TYPE	+(700°C~280°C) -(280°C~50°C)	-(700°C~280°C) +(280°C~50°C)	$\sim 2 \times 10^{16}$	350	500
0.05	22000	$9 \times 10^{18}$	N-TYPE	+(700°C~300°C) -(300°C~100°C)	-(700°C~300°C) +(300°C~100°C)	$\sim 6 \times 10^{16}$	150	400
0.05	10000	$1 \times 10^{18}$	N-TYPE	+(700°C~280°C) -(280°C~80°C)	-(700°C~280°C) +(280°C~80°C)	$\sim 5 \times 10^{16}$	250	450
0.05	5000	$4 \times 10^{18}$	N-TYPE	+(700°C~280°C) -(280°C~90°C)	-(700°C~280°C) +(280°C~90°C)	$\sim 3 \times 10^{16}$	500	600